STUDIES ON THE TOXICITY OF MIREX TO THE ESTUARINE GRASS SHRIMP, *Palaemonetes pugio*

by

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INTRODUCTION

Limited information exists concerning the effects of the polycyclic chlorinated insecticide Mirex (Dodecachlorooctahydro–1, 3, 4–metheno–2H–cyclobuta [*cd*] pentalene) on non-target organisms. Mirex is the active ingredient in a bait presently being used by the U.S. Department of Agriculture in the Southeastern states to kill the imported fire ant, *Solenopsis saevissima richteri* (Coon and Fleet 1970). The bait consists of 84.7% corn-cob grits, 15% soybean oil, and 0.3% Mirex. The approved application rate is 1.25 lbs. per acre per treatment. The use of this persistent pesticide is causing some concern, particularly in coastal areas dependent on estuarine productivity.

Mirex causes delayed mortality in blue crabs and pink shrimp. After a 96–hr. exposure to 0.1 parts per million Mirex solution, mortality in these animals reached 100% after a 3–week period (Lowe, Davison and Wilson 1970). Mahood et al. (1970) surveyed pesticide residues of blue crabs collected throughout the year in North Carolina, South Carolina, Georgia and Florida and reported that Mirex was second only to DDT in frequency of occurrence. Mirex exposure caused mass mortality and alteration of the developmental stages in the larvae of two crabs, *Rhithropanopeus harrisii* and *Menippe mercenaria* (Bookhout et al. 1972). None exposed to 10 parts per billion Mirex survived the megalops stage. Mortality approached 100% in crawfish in 5 days following a 144–hr. exposure to a 1 ppb Mirex solution (Ludke, Finley and Lusk 1971). Crawfish suffered a high mortality from granular Mirex through leaching and feeding. These crawfish accumulated residues 16,860–fold greater than the surrounding water into which the Mirex had leached.

Lowe et al. (1971) reported the toxicity of Mirex to brown shrimp, *Penaeus aztecus*; pink shrimp, *Penaeus duorarum*; blue crabs, *Callinectes sapidus*; fiddler crabs, *Uca pugilator*, and grass shrimp, *Palaemonetes pugio*. Adult fiddler crabs exposed to levels of Mirex bait equivalent to a field application had 73% mortality within 2 weeks. Juvenile brown shrimp and blue crabs died after exposure to one particle of 0.3% Mirex bait per animal. Using 0.3% bait on *Palaemonetes pugio*, Lowe et al. (1971) induced 70% mortality in 96 hrs.

with one particle of bait per shrimp and 100% mortality in 48 hrs. with five particles per shrimp.

Bodies of grass shrimp killed from exposure to one granule of 0.3% Mirex bait and then fed to blue crabs caused 100% mortality to the crabs within 2 weeks (Lowe et al. 1971). High residues in these crustaceans and mortality in crawfish fed Mirex-exposed *Gambusia* (Ludke, Finley and Lusk 1971) suggest the potential harmful side effects of the fire ant program to natural estuarine communities.

Estuarine grass shrimp (*Palaemonetes*) are common along the Gulf and Atlantic coasts (Faxon 1879, Gunter 1950, Williams 1965, Fleming 1967). These small decapods are found ranging through freshwater areas, brackish estuaries and into inshore saline waters where they are occasionally the predominant animal (Gunter 1950).

In view of the trophic significance of these shrimp, static system bioassays were made to determine the sensitivity of *Palaemonetes pugio* to Mirex in water and to 0.15% Mirex bait granules, since the USDA is continuing the fire ant control program but has plans in the future to substitute 0.15% Mirex bait for the 0.3% bait presently in use (J. I. Lowe 1972, personal communication).

MATERIALS AND METHODS

Grass shrimp, *P. pugio*, were netted in early fall from the dock area of the Gulf Coast Research Laboratory, Ocean Springs, Mississippi. All grass shrimp were held in a stock tank with 20 ppt salinity filtered and aerated sea water prior to the bioassays. Mortality was recorded and dead grass shrimp removed at 12-hr. intervals. Paralyzed shrimp were counted as dead, since they would be subject to abnormal predation in their natural environment. Approximately 10% were ovigerous; the average weight was 0.2 g.

Test solutions consisted of either filtered seawater or distilled water prepared with Rila marine salts, at 20 ppt salinity. Test vessels were 1-gallon glass jars, each containing 1 liter of solution and five grass shrimp. Technical grade Mirex was prepared in 0.1% acetone solution and serially diluted for experiments. The Mirex bait used was obtained from the USDA distribution center in Harrison County, Mississippi and was produced by Allied Chemical Company, Morristown, N. J. Solutions were constantly aerated through glass disposable pipettes. All tests were run at room temperatures of 20± 1°C.

Experimental procedures included the determination of the toxicity to grass shrimp of Mirex leached from bait granules (0.15% active ingredient) in water and through exposure to various concentrations of technical Mirex solution.

EXPERIMENTS AND RESULTS

Toxicity of Technical Grade Mirex

Samples of five shrimp were placed in each jar for three sets of nine jars with concentrations of .01 ppm, .1 ppm and 1 ppm Mirex. Samples of fifteen individuals were exposed for 48, 96, and 144 hrs. at each concentration and were then transferred to clean sea water. Controls were set up with an equivalent amount of acetone, but had no mortality throughout the test period. Rostrum–telson length of the shrimp averaged 26 mm.

Mortality began between 24 and 72 hrs. after the beginning of exposures to 1 ppm and .01 ppm respectively, with .1 ppm being intermediate in time to beginning of mortality. Exposure for 48 hrs. to .01 ppm caused 40% mortality during a 12–day period, including exposure time. A 100% mortality occurred in 6 days following a 96–hr. exposure to .1 ppm, and total death prevailed during a 96–hr. exposure to 1 ppm (Table 1). Symptoms exhibited by shrimp prior to death were irritability, uncoordinated movement, loss of equilibrium and spasmodic paralysis.

Toxicity from Mirex Granules

Juvenile (10–20 mm rostrum–telson length, avg. 15mm) and adult (avg. length 26 mm) *Palaemonetes pugio* were exposed to vary-

Table 1.

Percentage Mortality of *Palaemonetes Pugio* (N = 15, avg. length 26 mm) after initiation of exposure to various concentrations of technical Mirex

Mirex concen-tration	Exposure time (hours)	% Paralysis or death	Days after exposure initiation
.01 ppm	48	40%	12
.01 ppm	96	60%	12
.01 ppm	144	83%	12
0.1 ppm	48	91%	10
0.1 ppm	96	100%	10
0.1 ppm	132	100%	5.5
1 ppm	48	100%	5
1 ppm	96	100%	4
0 ppm	0	0%	12

Table 2.

Percentage Mortality of Grass Shrimp
(juveniles and adults during different exposure times to varying amounts of Mirex bait—0.15% active ingredient)

Granules per shrimp	Length (rostrum-telson)	Days of exposure	Paralysis or death	N
1	20-35 mm	10	43%	30
2	10-20 mm*	8	80%	15
2	20-35 mm	8	50%	15
5	10-20 mm*	8	100%	15
5	20-35 mm	8	67%	15
0	10-20 mm*	8	0%	10
0	20-35 mm	10	0%	15

* Juveniles, avg length = 15 mm
Adult avg length = 26 mm

ing amounts of 0.15% active ingredient Mirex bait (Table 2). Jars were set up as described above, and five to twenty-five granules of bait (avg. wt. = per granule of 1.2 mg) were added to each jar, equalling one to five granules per individual.

Exposure to one granule caused 43% mortality in 10 days to adult shrimp, two granules induced 50% mortality in 8 days, and five granules 67% mortality in 8 days. Juveniles had 80% mortality during an 8-day exposure to two granules, and 100% mortality during an 8-day exposure to five granules of 0.15% Mirex bait. Mortality began 36 hrs. after beginning of exposure. There was no mortality in the controls.

DISCUSSION AND CONCLUSION

Grass shrimp were found to be fairly sensitive to Mirex through direct and indirect exposure. Mortality increased with time and Mirex concentration and appeared to be correlated inversely with animal size. Exposure to all concentrations (.01 ppm–1 ppm) caused *Palaemonetes pugio* to suffer continuous delayed mortality for an extended period of time after the end of the exposure period (Fig. 1). Mortalities from exposure to technical Mirex solutions ranged from 40% in 12 days from a 48–hr. exposure to .01 ppm, to 100% during a 96–hr. exposure to 1 ppm.

Lowe, Davison and Wilson (1970) demonstrated that crabs suf-

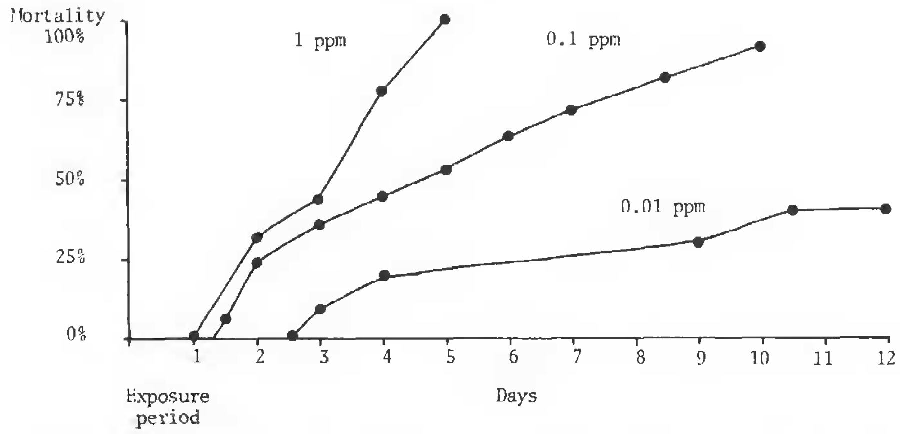

Figure 1. Mortality in grass shrimp caused by a 48-hour exposure to 1 ppm, 0.1 ppm and 0.01 ppm Mirex solutions. Mortality continued well after the end of the exposure period.

fered mortality in clean water after a 96–hr. Mirex exposure. This delayed continuous mortality was also found in crawfish (Ludke, Finley and Lusk 1971) and penaeid shrimp (Lowe, Davison and Wilson 1970).

Extensive mortality occurred in test populations exposed to 0.15% Mirex bait. Exposure to fewer granules decreased the amount of mortality in a given time period. Though mortality was not as great or as rapid as in tests using 0.3% bait on *P. pugio* (Lowe et al. 1971), it appears that significant toxicity is exhibited by the 0.15% Mirex fire ant bait in spite of its reduction in insecticide content.

Water contamination by chlorinated hydrocarbon insecticides through runoff from treated areas in Mississippi (Finley, Ferguson and Ludke 1970), the resistance of Mirex to degradation, and its tendency to move into water by leaching would indicate the high probability of contamination in treated watersheds. Upon reaching Gulf coastal areas (with possible mortality to fresh water shrimp on the way) Mirex-contaminated water could prove destructive to grass shrimp populations since their habitat is associated with estuarine shorelines. The abundance of grass shrimp in coastal shallows (Gunter 1950) indicates their ecological significance.

Mirex-induced mortality in estuarine *Palaemonetes* could prove detrimental to the estuarine ecosystem. This might affect the Gulf's commercial fisheries, since estuaries are the nurseries of many economically important marine animals and estuarine species make up about 97.5% of the total commercial fisheries catch of the Gulf States (Gunter 1967).

In addition, the toxicity of Mirex through trophic levels (Ludke, Finley and Lusk 1971, Lowe et al. 1971), its persistence in the tissues of fish (Lowe, Davison and Wilson 1970) and the usually high toxicity of chlorinated hydrocarbons to copepods, shrimp and crabs (Butler 1964) should be considered in evaluating the potential importance of Mirex as a pollutant in the estuarine ecosystem. The present indications are that it is extremely harmful to crustaceans of all kinds.

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